

Dispersion of Amorphous $\text{Sn}_2\text{P}_2\text{O}_7$ in
a Conductive Matrix as an Anode
Material in Lithium Secondary
Batteries

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Tin-based materials may offer alternatives to anode materials in lithium secondary batteries, because of their higher gravimetric/volumetric capacity compared to graphite, a widely used anode. However, metal tin and tin oxides normally suffer substantial loss of capacity due to mechanical degradation during cycling. Dispersion of tin in a non-active or less active matrix was suggested to alleviate the capacity fading. Accordingly, Sn-based alloys[1], Sn-based materials dispersed in conductive matrixes[2], and Sn-based glasses[3] were prepared. Among them, Fuji TCO glass[3] has demonstrated superior properties in specific capacity ($\sim 650 \text{ mAh/g}$ at C/12) and cycling stability.

We report here on a composite: amorphous $\text{Sn}_2\text{P}_2\text{O}_7$ dispersed in a conductive carbon matrix ($\text{Sn}_2\text{P}_2\text{O}_7/\text{C}$) as the anode material. Carbon was chosen as the matrix, because it offers advantages in low atomic mass, which leads to low weight percentage needed for matrix, thus maintaining the high capacity of the active material, and good electronic conductivity, which helps obtain good rate sustention. Crystalline $\text{Sn}_2\text{P}_2\text{O}_7$ (Aldrich, 99%) was blended with a polymer gel. The mixture was then treated at a high temperature, and was subsequently quenched to room temperature to obtain amorphous $\text{Sn}_2\text{P}_2\text{O}_7$ dispersed in a carbon matrix.

Fig.1 shows discharge/charge profiles of the composite at a rate of $\sim \text{C}/10$. The capacity for the first discharge was 894 mAh/g ($6.93 \text{ Li}/(\text{Sn}_2\text{P}_2\text{O}_7)$), and for the first charge was 505 mAh/g ($3.92 \text{ Li}/(\text{Sn}_2\text{P}_2\text{O}_7)$). The capacity loss mainly due to the irreversible formation of Li_2O is $\sim 42\%$, and has been typically observed for active materials based on Sn-P-O and Sn-B-P-O glasses. Following cycles displayed good capacity retention and good charge/discharge efficiency.

Cycling stability tests of this composite were conducted at a rate of $\sim \text{C}/2$ in potential ranges of $0.0 - 1.5 \text{ V}$ and $0.1 - 0.8 \text{ V}$, shown in **Fig. 2** as curve **a** and curve **b** respectively. In curve **a**, the initial capacity at C/2 is similar to the value at C/10 (see **Fig. 1**), indicating a good rate sustention for this composite. After 50 cycles, the capacity maintained 73% of the second discharge capacity (e.g. $Q_{50}/Q_2 = 73\%$). For curve **b**, which has a narrow potential window, it had a lower capacity ($Q_2 = 366 \text{ mAh/g}$), but exhibited better cycling stability with $Q_{50}/Q_2 = 81\%$.

Reference:

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[2] J. Santos-Pena, T. Brousse, and D. M. Schleich, *Solid State Ionics*, **135**, 87 (2000)
[3] Y. Idota, T. Kubota, A. Matsufuji, Y. Maekawa, and T. Miyasaka, *Science*, **276**, 1395 (1997)

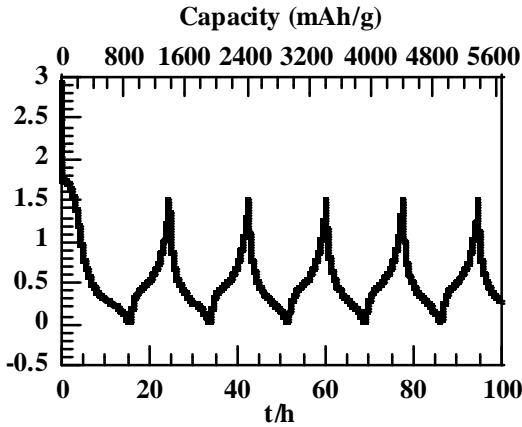


Fig.1 Initial cycles of $\text{Sn}_2\text{P}_2\text{O}_7/\text{C}$ composite. Potential: $0.0\text{-}1.5 \text{ V}$; Rate: C/10

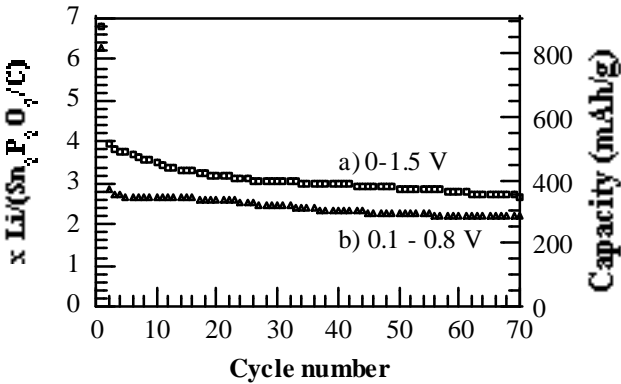


Fig. 2 Cycling stability of $\text{Sn}_2\text{P}_2\text{O}_7/\text{C}$ composite at C/2 rate in the potential range of **a)** $0.0 - 1.5 \text{ V}$; and **b)** $0.1 - 0.8 \text{ V}$